

## The World has changed ....

Old School:  
Moore's Law

### ***Focus on the product***

- MHz matters
- Engineering first, customer second

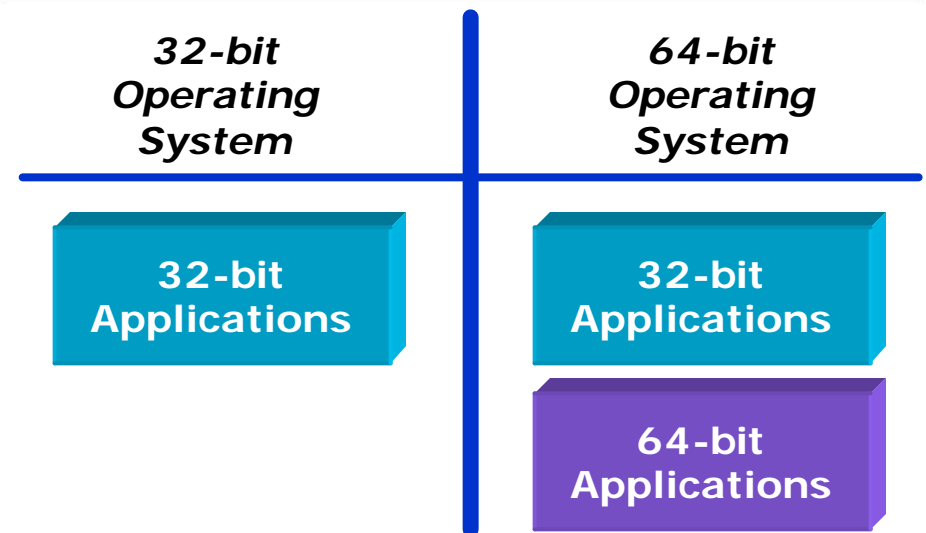
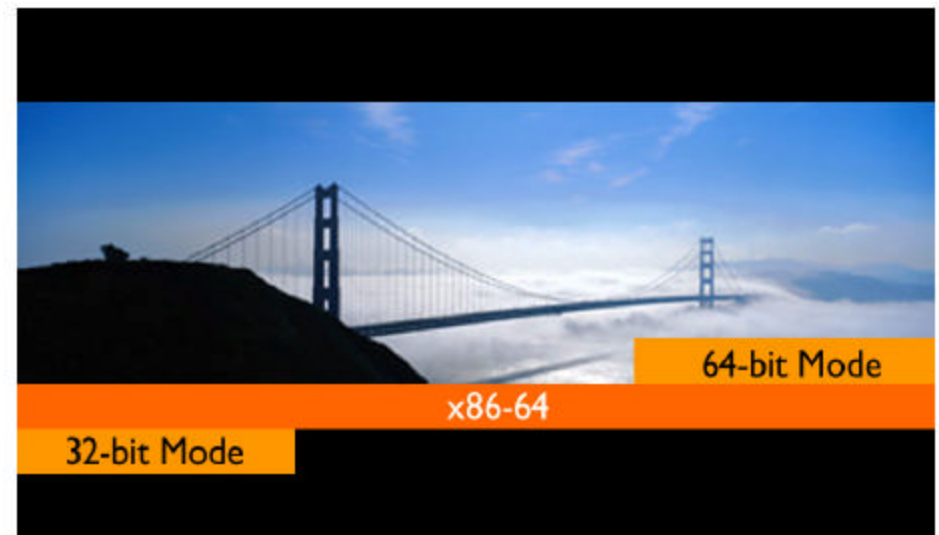
New School:  
Customer-*centric* Innovation

### ***Focus on the customer***

- ✓Reduced TCO
- ✓Investment protection
- ✓Platform Image Stability
- ✓Greater Value
- ✓Lifecycle improvements

# AMD Builds a Bridge to the 64-bit World

- Provides investment protection for users who have invested in 32-bit application software
- Current 32-bit applications will work on today's 32-bit operating systems as well as tomorrow's 64-bit operating systems
  - Windows XP
  - Windows 2000
  - Windows (with AMD64 compatibility)
  - Windows Server 2003
  - Linux for x86
  - Linux for AMD64
- Enables a gradual application transition to 64-bits as required by end-user individual needs.
- Doesn't require special hardware or investment in a proprietary infrastructure



# AMD Opteron™

## Three Major Performance Innovations

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### AMD64 Technology

- Introducing 64-bit technology that is an extension of the x86 32-bit world
- No “Migration Tax”

### Integrated Memory Controller

- No longer in the Northbridge, the memory controller is now in the processor
- Eliminates memory performance bottlenecks

### HyperTransport™ Interface

- Driving on-board chip-to-chip communication to new levels of performance
- Lower cost PCB solutions

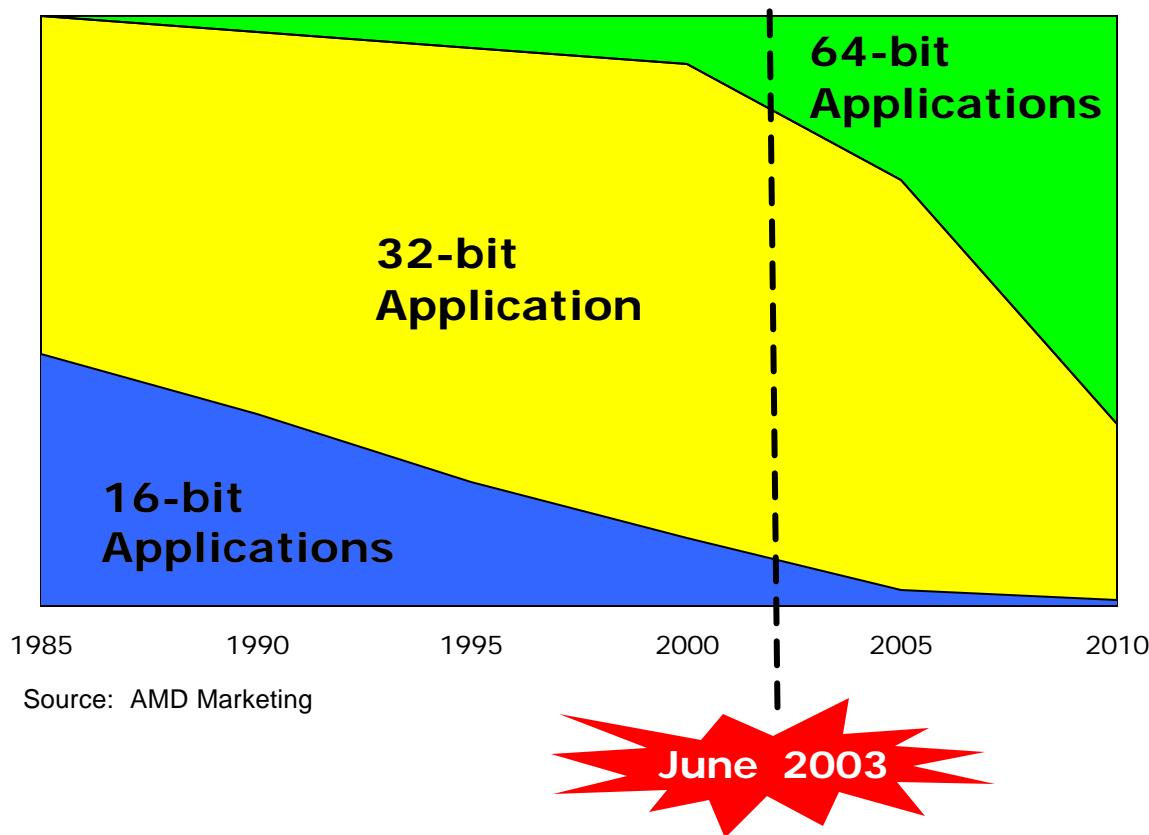




# Software Discussion

# AMD Opteron™ Processor Ecosystem

## A new era in 64-bit computing



- Most applications will remain 32-bits for the near-term future
- AMD Opteron offers compatibility AND performance for 32-bit applications
- Applications that need 64-bit memory addressing or computational capabilities have a flexible migration path
- ISVs have freedom to choose the best architecture for their applications
- Users have one platform that can run any type of software available for the x86 architecture

# Intel's IA-64 "Migration Tax"



## Understanding the costs of migrating from x86 to IA-64

- Significant cash investment
  - New Hardware, Software certification, training, services
  - New instruction set requires steep learning curve
  - Downtime during migration
  - Cost to rewrite and implement new administration policies
  - Y2K revisited – research shows that the average migration project involves 100,000 lines of code, a four- to six-month time frame, and costs \$821,000<sup>1</sup>.
  - Legacy applications must either migrate or perform poorly in emulation mode
- Optimization requires intimate compiler knowledge

<sup>1</sup> (Aberdeen Group – "Strategically Attacking Software Sclerosis" An Executive White Paper February 2001)

# AMD Opteron™ Processor Ecosystem

**Most 32-bit software does not need to be ported!**



- Immediately compatible because AMD Opteron™ natively supports x86 instruction set
- Takes full advantage of core enhancements offered by AMD Opteron™
- Gets increased performance today as seen by 3<sup>rd</sup> party benchmarks – and is expected to run faster every year as systems speed up

## Targets for 32-bit software:

- Risk-averse users like most Enterprise IT
- Users migrating from Windows NT to Windows Server 2003 or Linux who want to maintain a 32-bit environment
- Users looking for increased performance for existing 32-bit applications
- SMBs wanting the benefits of Enterprise computing without a 64-bit price tag

# AMD Opteron™ Processor Ecosystem

## 64-bit software support



- Operating systems, development tools, and device drivers are being ported, which provide the necessary infrastructure for running 64-bit applications or a mixture of 32/64 applications
- Applications that handle lots of data, users, and transactions
- Kernel-level programs must be ported, such as device drivers
- Programs that will share in-memory data structures with a 64-bit program must be ported, such as the plug-in software components for 3D modeling and CAD applications

### Target for 64-bit computing:

- Early adopters like HPC community or Enterprise technical computing
- Users wanting to migrating from UNIX to 64-bit Linux or Windows
- 32-bit Linux and Windows users who need to move to 64-bit computing
- Enterprises that are evaluating Linux



# AMD Opteron™ Processor Ecosystem

## Software that will benefit from porting to 64-bit



### •Apps that handle large data files

- 2D/3D CAD, CAM, CAE, and EDA (workstation)
- Modeling, animation, and simulation (workstation and server)
- Digital Imaging (workstation)
- Electronic publishing (workstation)
- Video Editing (workstation)
- Games (client & server)
- Searching/indexing (client, workstation, & server)
- Rendering Engines (workstation & server)
- Streaming Media Engines (client, workstation, & server)

### Apps that need large memory addressing

- Large data sets (client, workstation, & server)
- Financial modeling (client, workstation. & server)
- Scientific and technical applications (workstation & server)
- Host-based desktop applications (server)
- Running multiple instances of applications simultaneously (server)

### Apps that serve many transactions/users

- Database Engines (workstation & server)
- Web Servers (server)
- Email Servers (server)

**Port Only Those Applications  
That Make Sense!**

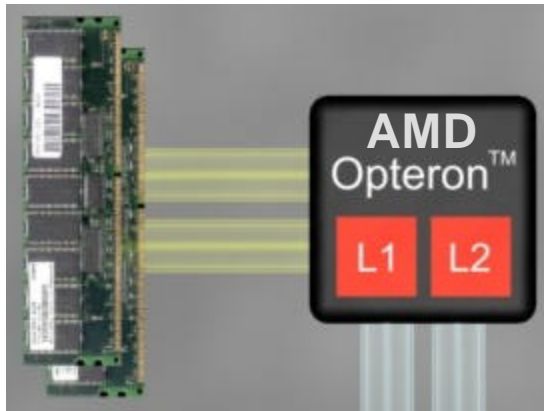


# System Architecture

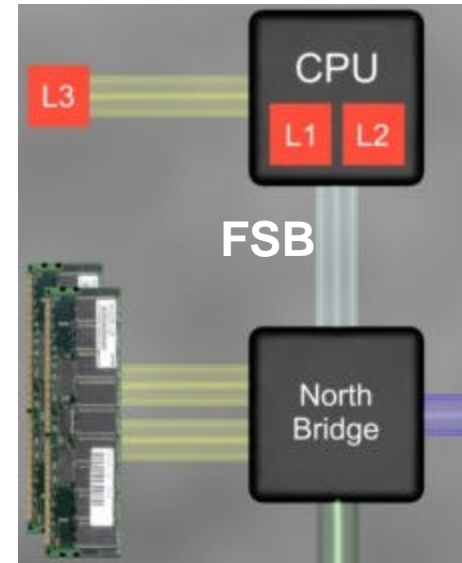
# Integrated Memory Controller



*1,000's of MHz  
& Always Increasing*



*100's of MHz  
& Slowly Improving*



- AMD's Integrated Memory Controller runs at the CPU Core Frequency
  - As the CPU frequency increases, Opteron™'s memory controller becomes more efficient
  - Each CPU has dedicated bandwidth
  - Bandwidth increases with more CPU's

- Itanium, Pentium® 4, & Xeon
  - Memory performance scales with the FSB frequency
  - Additional CPU's share bandwidth and make problems worse

# HyperTransport™ Technology

## Overview



- High performance chip-to-chip interface
- Scaleable/flexible to support a wide range of speed and power requirements
- **Full PCI software compatibility – Transparent to applications and operating systems**
- Supports up to 31 devices
- Open standard - no licensing fee or royalty
- Allows building block approach to system design
- Reduces the number of proprietary buses
- Cost efficient



# HyperTransport™ Technology

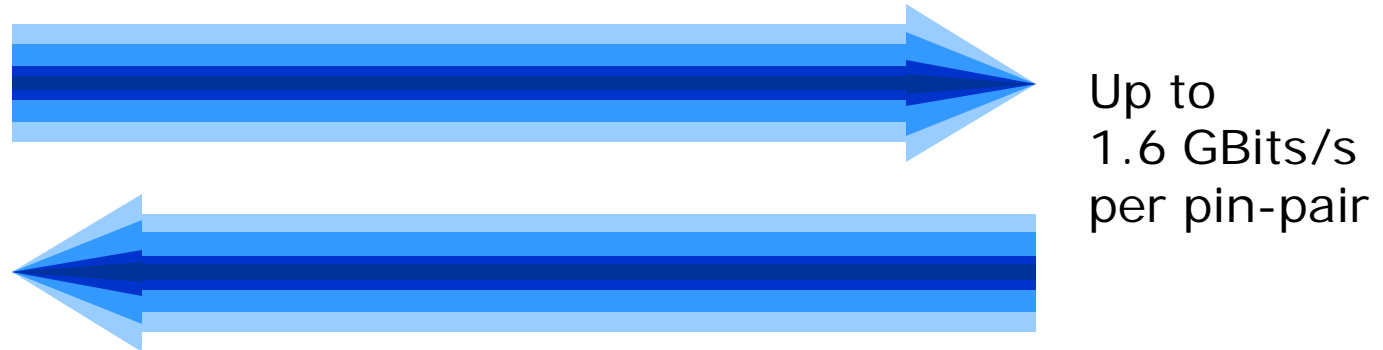
## Design Goals



- Maintain compatibility with legacy systems
  - **Complement standard buses**
  - **Little or no impact on existing operating systems and drivers**
- Provide increased I/O bandwidth
- Reduce data bottlenecks by moving slower devices out of critical information paths
- Reduce the number of buses within the system
- Simplify system design – “Glueless” CPU interconnect
- Use as few pins as possible to lower cost and reduce package size
- Help ensure low latency responses
- Reduce power consumption

# HyperTransport™ Technology

## Scalable Link Width & Speed



### **Links operate in one direction only**

- 2, 4, 8, 16, or 32 bits wide at 200Mhz to 800Mhz Double Data Rate
- Narrower Devices can talk to wider devices
- Width and speed negotiation at initialization

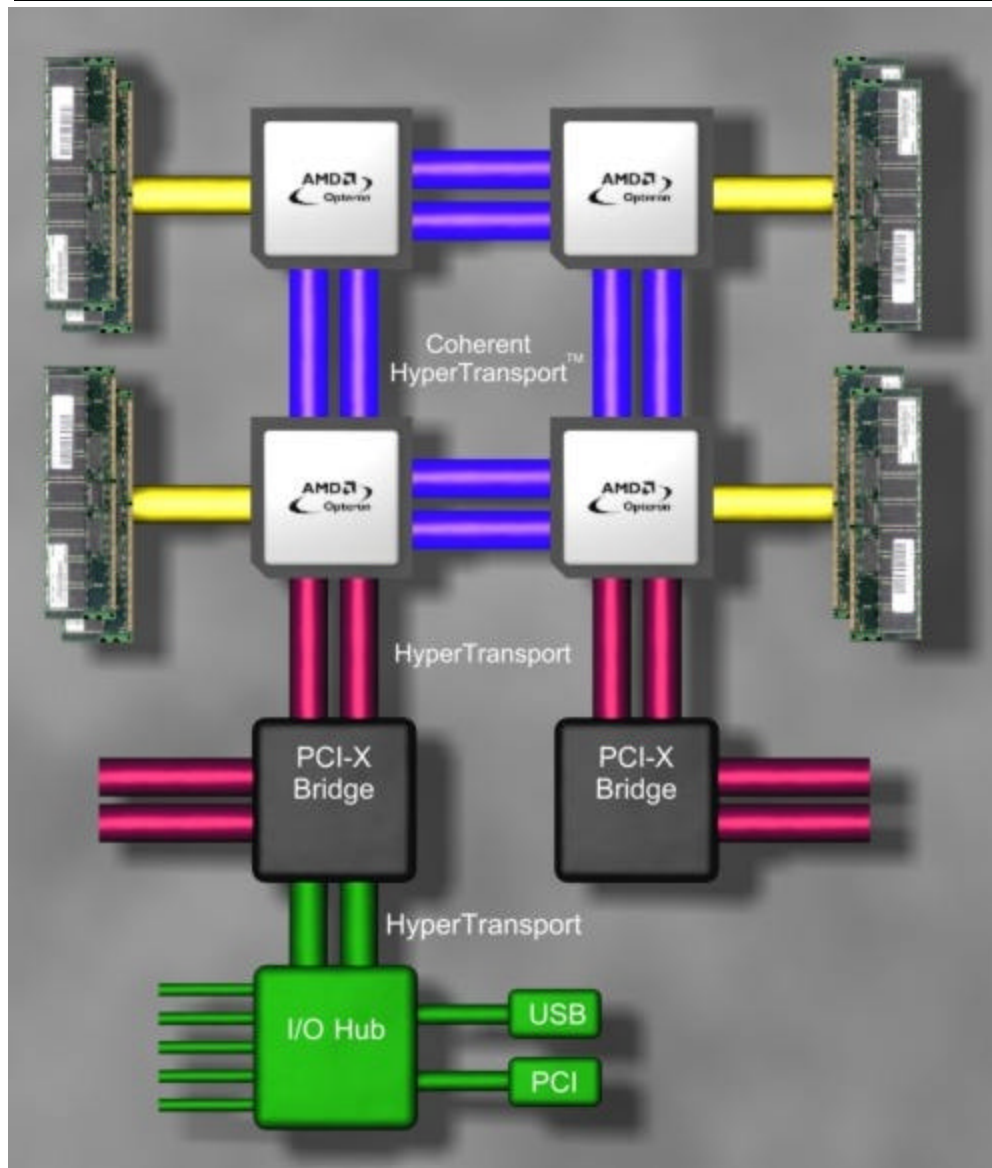
### **Data is packetized**

- Packets are multiples of 4-Bytes
- Serial Interface with commands, address, and data using the same wires

- **HyperTransport™ links can be one of two types:**
  - Coherent (for CPU-to-CPU communication)
  - I/O (for peripheral and bus communications)
- **CPUs within multiple CPU environments must know what data is held in each of the other CPUs' caches**
  - Cache memory contains a copy of system memory data
  - CPUs must be aware of other CPU's having the required data in their caches
  - Coherency prevents CPUs from having different versions of the same data in their caches
  - Coherent HyperTransport links provide a communications mechanism to make sure all CPU caches have the most current copy of data



# “Glueless” Multi-CPU Design



## HyperTransport™:

- Point-to-point link
- Allows for “glueless” multi-CPU designs
- Each CPU adds memory and HyperTransport bandwidth
- Three (coherent capable) HyperTransport links per AMD Opteron™ CPU (8xx Series)
- Scales to an 8-way without additional glue logic

# Simplified System Design

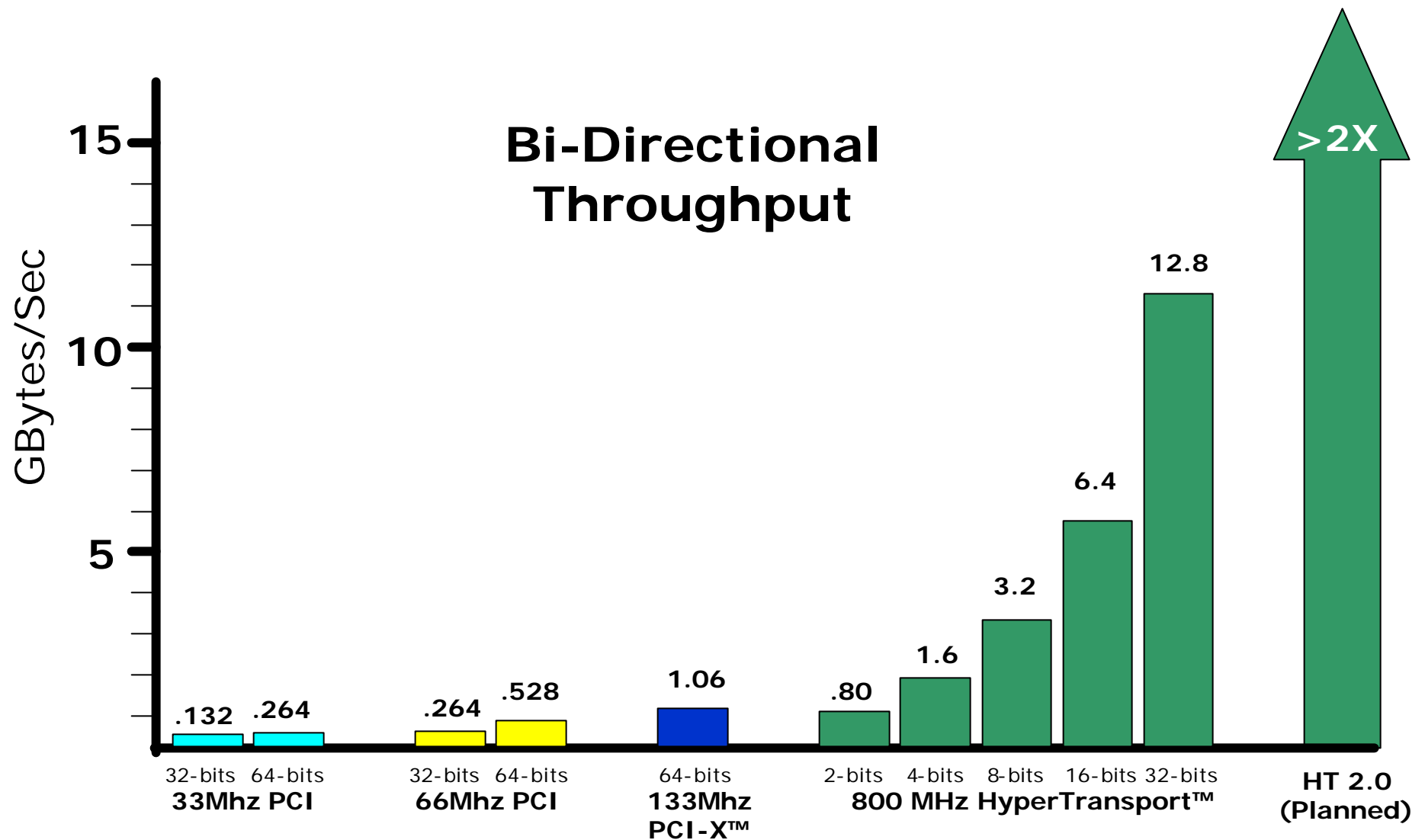
## 11 Chipsets vs. One



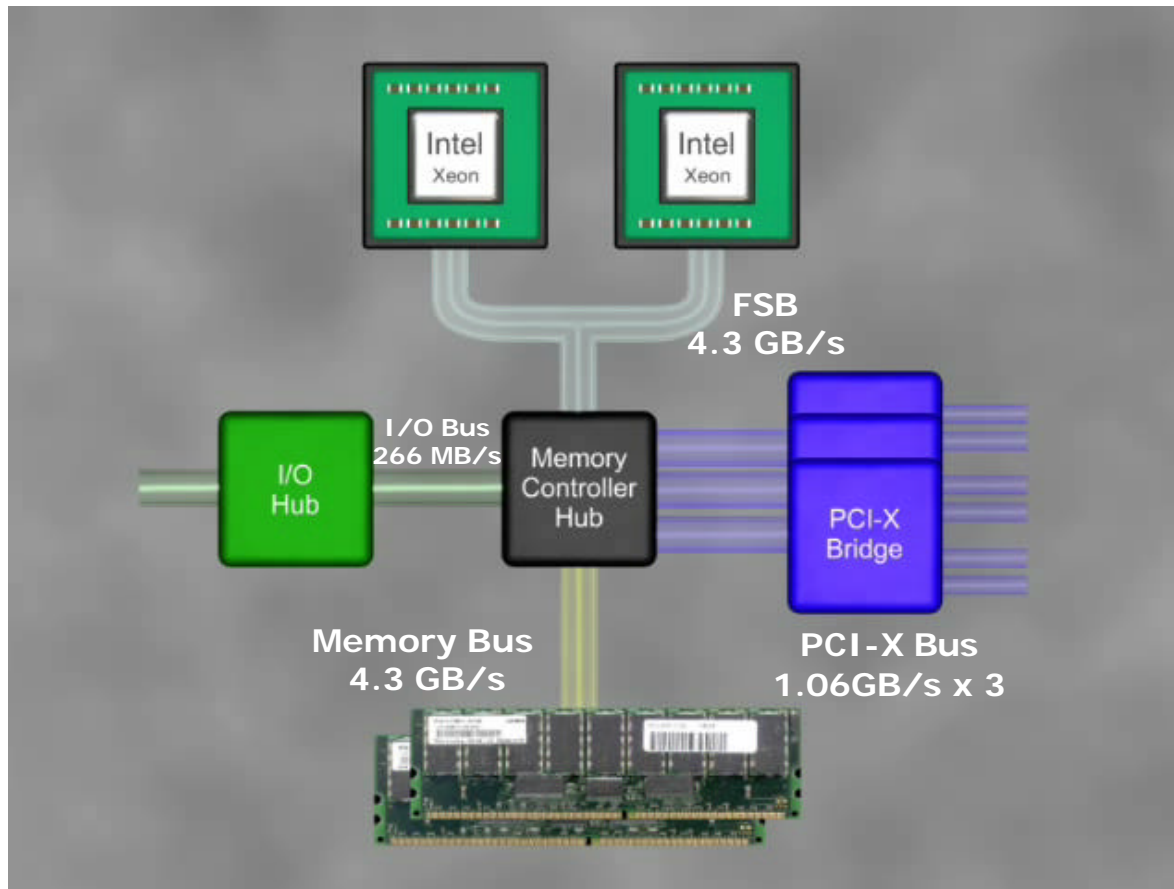
	Intel CPU & Chipsets	AMD Opteron™ CPU & Chipset
1P	<b>Pentium® 4</b>  845 845GE 845P 875P	<b>Model 14x</b>  AMD-8100™
2P	<b>Xeon</b> Serverworks GC-LE GC-SL Intel E7500 E7501 860	<b>Model 24x</b>  AMD-8100
4P	<b>Pentium III, Xeon MP</b> Serverworks GC-HE ServerSetIII HE	<b>Model 84x</b>  AMD-8100

# HyperTransport™ Technology

## Scalable Bandwidth



# Xeon DP - Lightly Loaded



Animation

(2) Xeon = 8.6 GB/s  
(3) PCI-X Bus = 3.2 GB/s  
I/O Bus = 266 MB/s  

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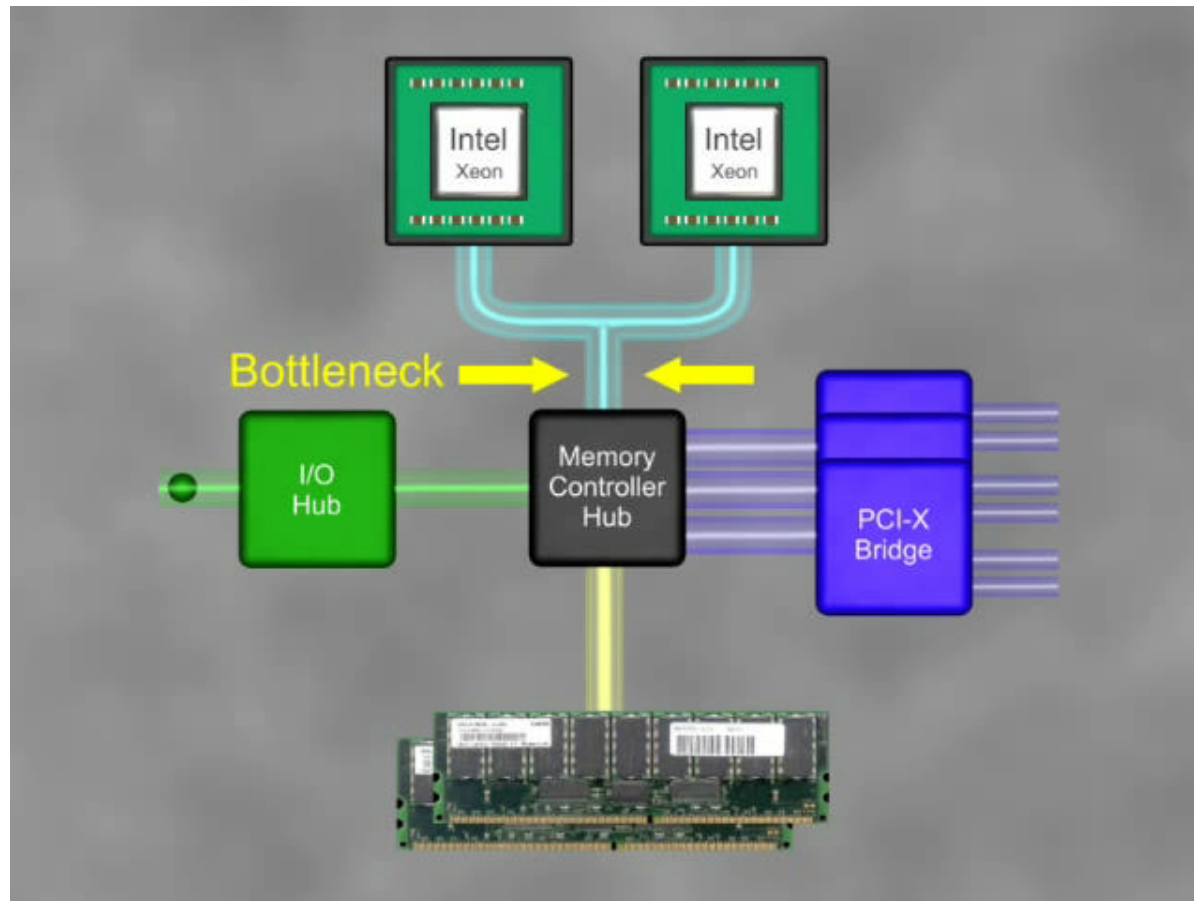
**Total Demand = 12.1 GB/s**

**FSB Total Available**  
533MHz x 8 Bytes  
**= 4.3 GB/s**

- Architecture works well when not heavily loaded
- Large caches and Hyper-Threading may help minimize impact

Worst case scenario  
based on the E7501  
chipset with DDR266

# Dual Xeon – Heavily Loaded



Animation

(2) Xeon = 8.6 GB/s  
(3) PCI-X Bus = 3.2 GB/s  
I/O Bus = 266 MB/s  
**Total Demand = 12.1 GB/s**

**FSB Total Available**  
533MHz x 8 Bytes  
**= 4.3 GB/s**

## FSB is the bottleneck

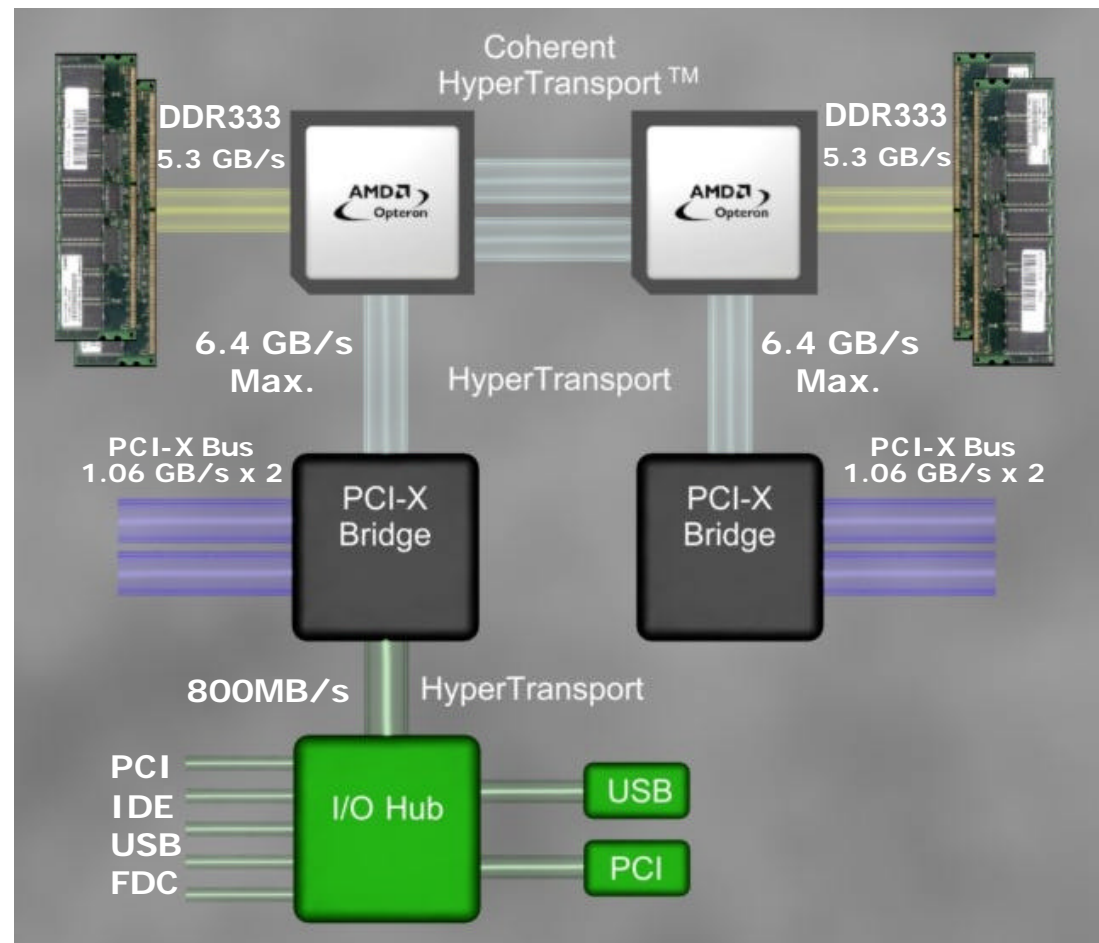
- Each CPU gets  $< \frac{1}{2}$  of max bus bandwidth
- Memory and I/O must share the same bus
- Adding CPUs compounds problems
- Not very scalable past 2-way

Worst case scenario  
based on the E7501  
chipset with DDR266

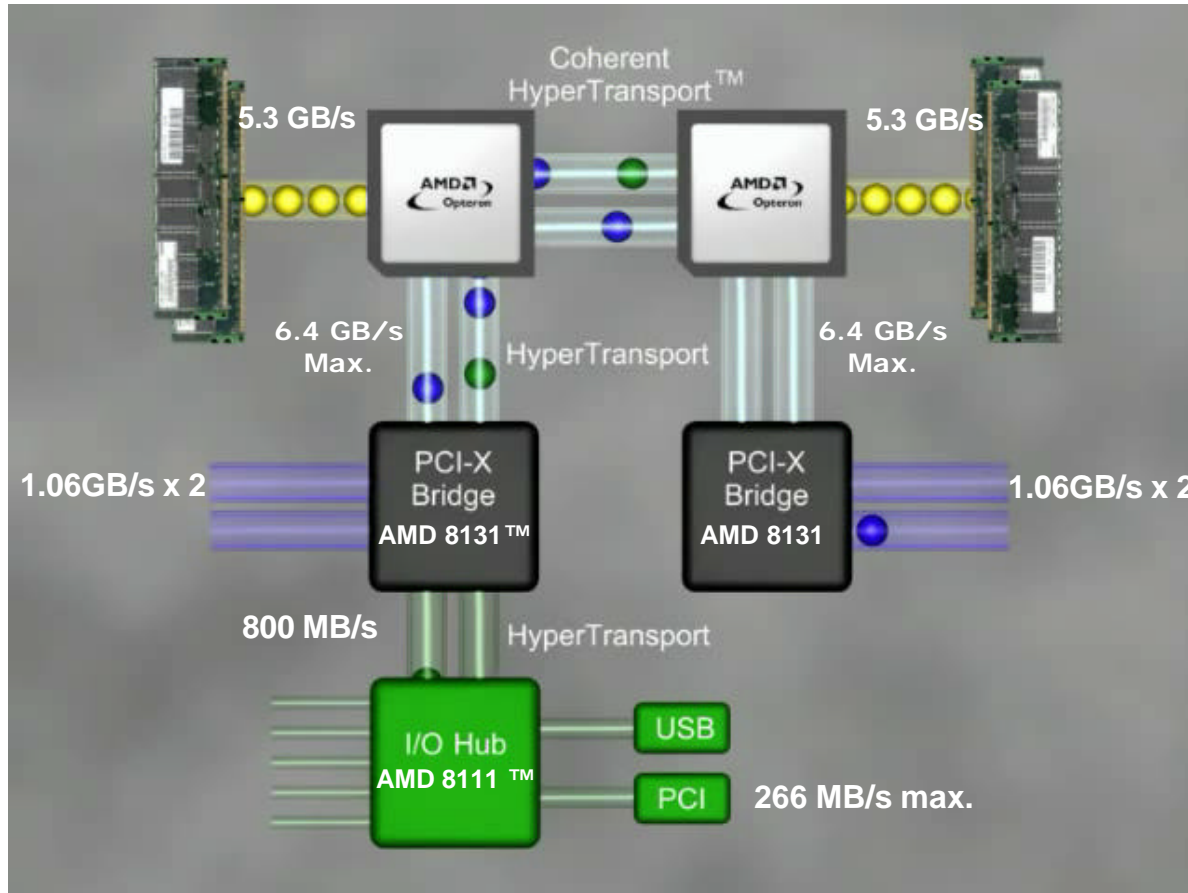
# Increasing System Performance the AMD way



- Increase processor, bus, device speeds
- Integrate memory controller into CPU
  - Dedicated bandwidth to memory
  - Decreases latency and bus contention
  - Adding CPUs adds memory bandwidth
- Implement HyperTransport™
  - Less latency for chip-to-chip communications
  - CPUs can communicate with each other without getting on main bus to memory and peripherals
  - Bandwidth scales with each new CPU added



# Dual AMD Opteron™ – Heavily Loaded



Animation

Worst case scenario  
based on the 8100  
chipset with DDR333

- All bottlenecks reduced or eliminated
- Each CPU has 5.3 GB/s dedicated memory bandwidth
- CPU-to-CPU cHT offer bandwidth of 3.2GB/s each direction
- Each PCI-X Bus has bandwidth of 3.2GB/s each direction
- I/O is independent of memory access
- Adding CPUs adds memory and I/O bandwidth



# AMD Opteron™ Processor Specs

## Server Motherboards and Solutions -



### Motherboards

Platform	<b><u>Arima (Rioworks) HDAMA</u></b>
Processor	<b>AMD Opteron™ 200 Series</b>
Chipset	<b>AMD-8131™/AMD-8111™</b>
Memory	<b>DDR 333/266/200 (6 DIMMs)</b>
FF	<b>eATX</b>
Graphics	<b>ATI Rage XL Video Controller</b>
I/O	<b>3xPCI-X, 2xPCI, GbE LAN, 4xUSB</b>
Availability	<b>Now</b>

Platform	<b><u>MSI K8D Master</u></b>
Processor	<b>AMD Opteron 200 Series</b>
Chipset	<b>AMD-8131/AMD-8111</b>
Memory	<b>DDR 333/266/200 (6 DIMMs)</b>
FF	<b>eATX</b>
Graphics	<b>ATI Rage XL Video</b>
Controller	
I/O	<b>3xPCI-X 100MHz, 2xPCI GbE LAN, 4xUSB</b>
Availability	<b>Now</b>

Platform	<b><u>Tyan Thunder K8S</u></b>
Processor	<b>AMD Opteron 200 Series</b>
Chipset	<b>AMD-8131/AMD-8111</b>
Memory	<b>DDR 333/266/200 (6 DIMMs)</b>
FF	<b>eATX</b>
Graphics	<b>ATI Rage XL Video Controller</b>
I/O	<b>2xPCI-X 100MHz, 2xPCI-X 66MHz, 1xPCI, 2xGbE LAN, 4xUSB</b>
Availability	<b>Expected June'03</b>

*Please contact the respective vendors directly for the latest schedules and information.*

### Solutions

Platform	<b>Newisys 4300</b>
Processor	4P AMD Opteron
Memory	DDR-333 (4DIMMS/CPU)
Physicals	3U
I/O	7 PCI-X (3 + 4 hot-swap) slots
Management	Service Processor/Remote Mgmt

Platform	<b>Newisys 2100</b>
Processor	2P AMD Opteron 200 Series
Memory	DDR-333 (4DIMMS/CPU)
Physicals	1U
I/O	PCIX, 2xGig Ether, SCSI
Management	Service Processor/Remote Mgmt

Platform	<b>A8440</b>
Processor	4P AMD Opteron 800 Series
Memory	DDR-333 x4 each
Physicals	4U N+1 PSU
I/O	PCIX, 2xGig Ether, SCSI
Management	IPMI 1.5/Remote Mgmt LAN

Platform	<b>A2210</b>
Processor	2P AMD Opteron 200 Series
Memory	DDR-333 x4 each
Physicals	1U
I/O	PCIX, 2xGig Ether, SCSI optional
Management	IPMI optional, Remote Mgmt optional

**Available in NA  
& Europe only**





# Benchmark Discussions

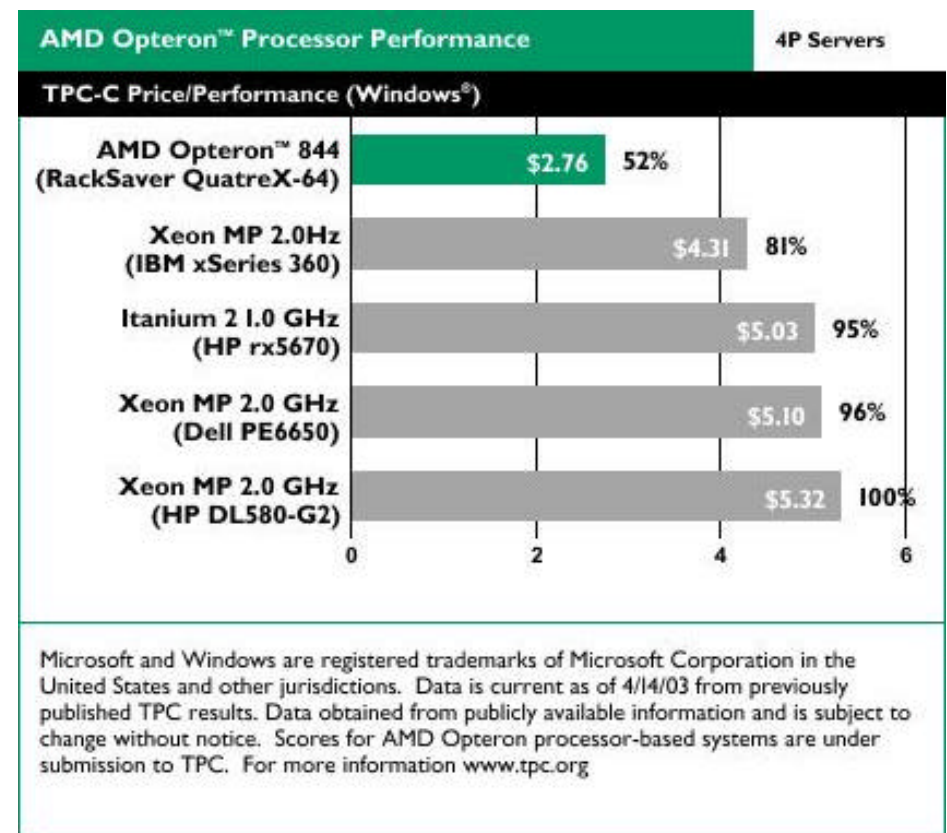
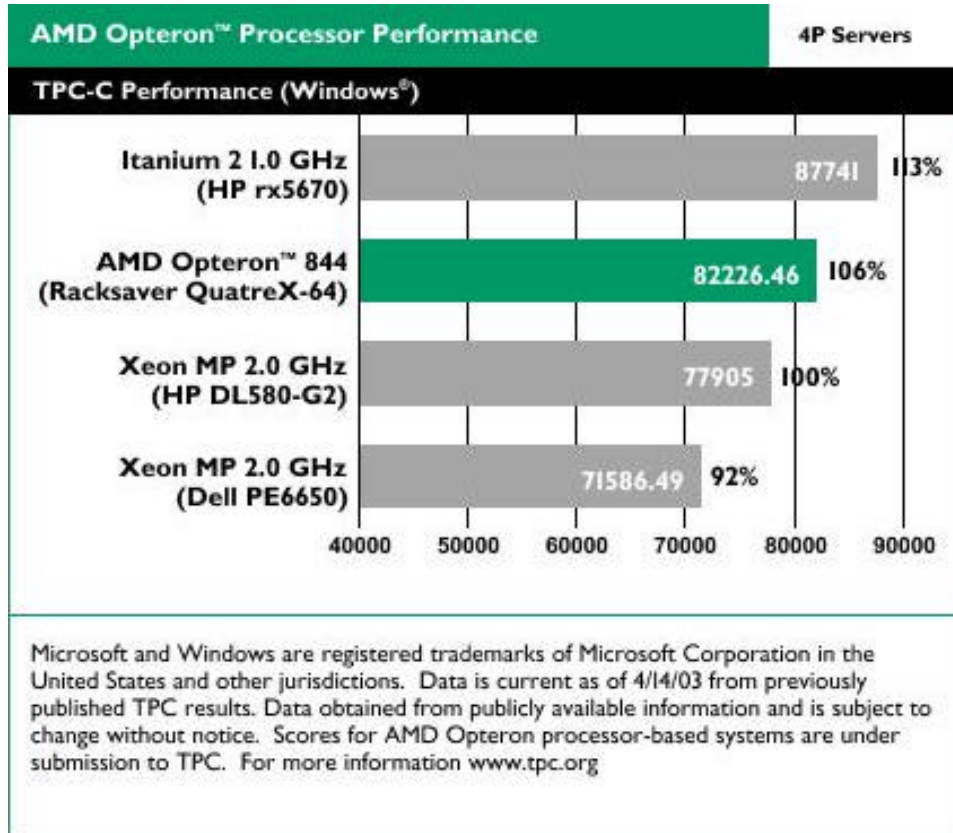
## AMD Opteron™ processors are in the highest performing SPEC benchmark 2P and 4P servers

- Highest recorded 2P and 4P SPECweb® 99 scores, breaking for the first time the 10,000 barrier on a 4P system
- Highest recorded 2P and 4P SPECint®\_rate2000 scores
- Best scaling 1P to 2P to 4P SPECfp®\_rate2000 scores
- Highest recorded 4P SPECweb 99\_SSL scores
- Highest recorded 1P, 2P, and 4P SPECjbb® 2000 scores

Source: [www.spec.org](http://www.spec.org); Results as of May 22, 2003

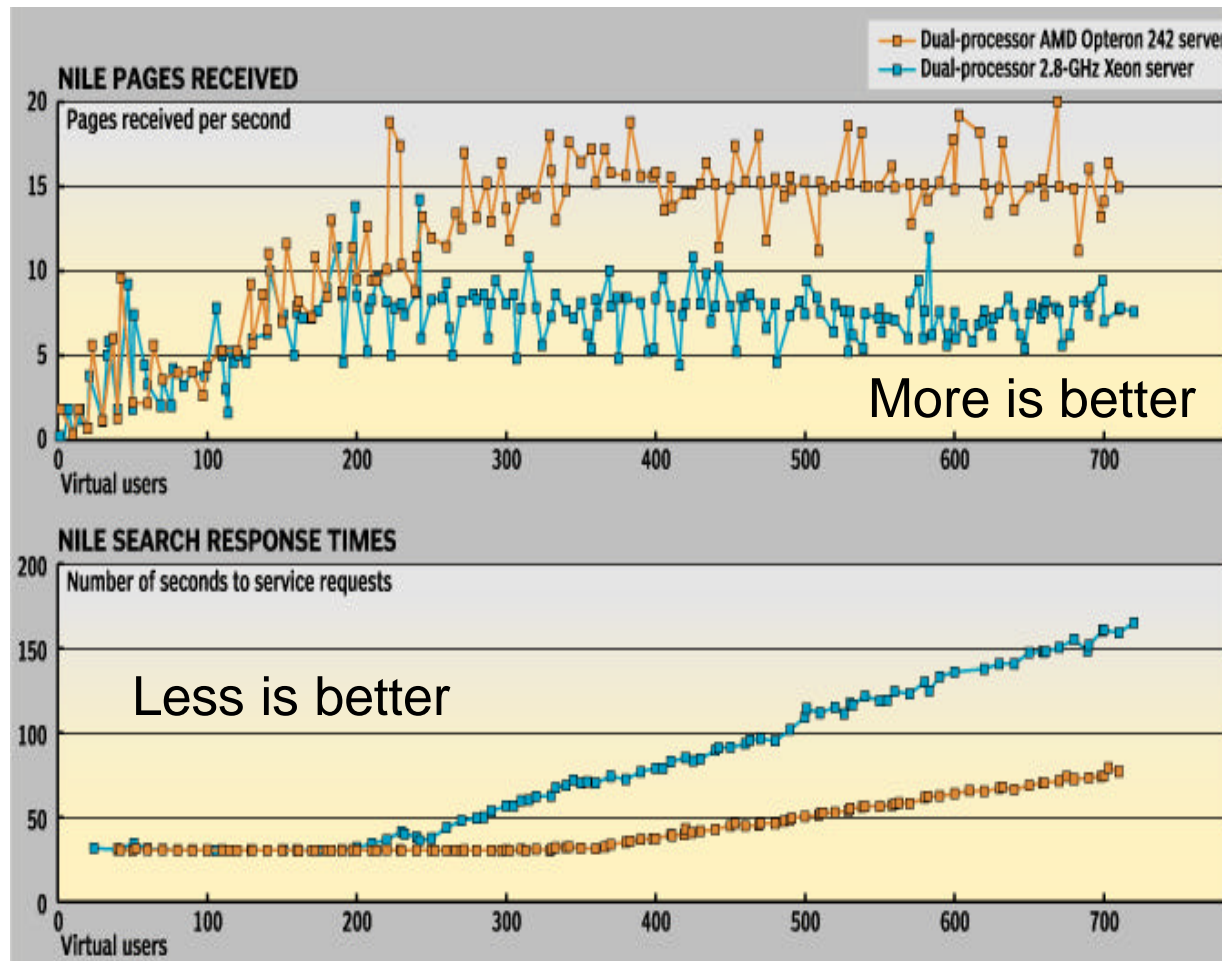
# TPC-C Benchmarks

## 4-Way



# AMD Opteron™ - Performance Leader

## 2-Way Benchmark Comparison



- Dual 2.8 Ghz Xeon vs. dual Opteron 242
- Benchmark simulates transactions for an online bookstore
- Oracle 9i, BEA Weblogic Server, Windows 2000 SP3
- CPU and Disk-intensive
- 32-bit mode
- **Outperforms Xeon almost 2-to-1**

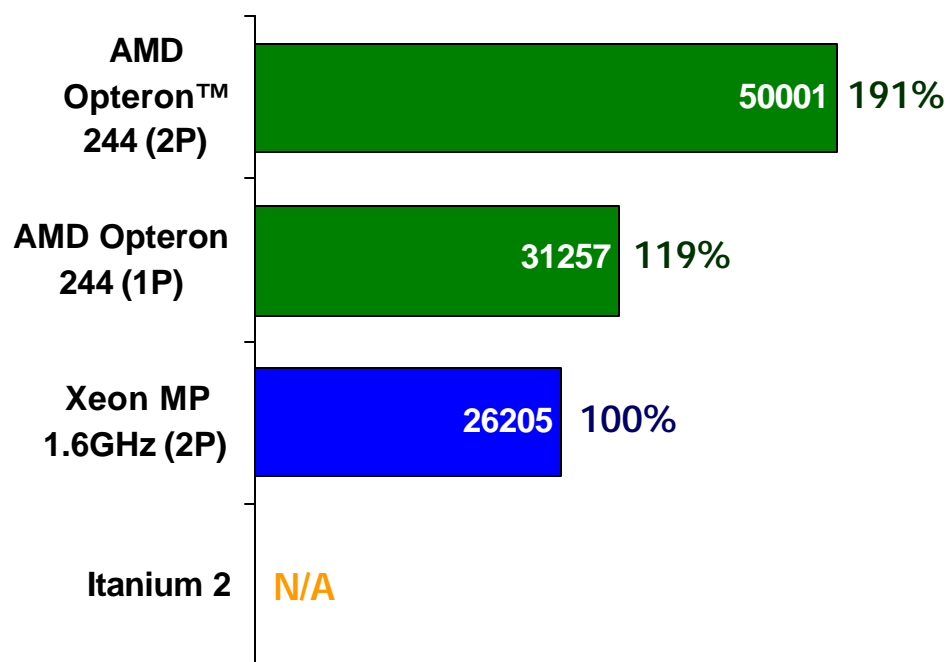
Source: PC Magazine, "AMD Opts for 64-Bit Computing" May 7, 2003

<http://www.pcmag.com/article2/0,4149,1061586,00.asp>

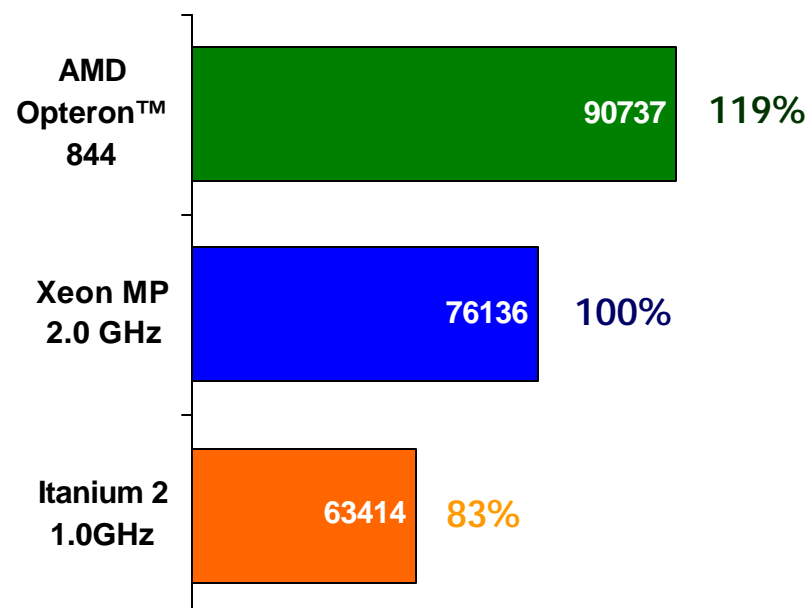
# Java Application Server Performance



**SPECjbb™2000 Performance  
(1P & 2P Servers, Linux)**



**SPECjbb™2000 Performance  
(4P Servers)**



[www.amd.com/opteronperformance](http://www.amd.com/opteronperformance)



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# Microsoft Exchange 2000

## 32-bit Benchmarks



Performance Benchmarks					
Date of Test	Server	Processor Type	No. of Processors	Processor Speed (MHz)	MMB2 <sup>1</sup>
April 2003	<a href="#">RackSaver QuatreX-64</a>	AMD Opteron <sup>2</sup>	4	1,800	15,520
January 2003	<a href="#">IBM eServer xSeries 360</a>	Xeon MP	4, with Hyper-Threading enabled	2,000	13,200
October 2002	<a href="#">Dell PowerEdge 6600</a>	Xeon MP	4, with Hyper-Threading enabled	2,000	13,000
June 2002	<a href="#">Compaq ProLiant DL580 G2</a>	Xeon MP	4, with Hyper-Threading enabled	1,600	11,400
July 2002	<a href="#">Dell PowerEdge 6650</a>	Xeon MP	4, with Hyper-Threading enabled	1,600	11,304
March 2002	<a href="#">IBM eServer xSeries 440</a>	Xeon MP	4, with Hyper-Threading enabled	1,600	11,300
June 2002	<a href="#">IBM eServer xSeries 255</a>	Xeon MP	4, with Hyper-Threading enabled	1,600	11,200

<sup>1</sup> MMB2 is a new benchmark for a significantly increased workload that employs increased message sizes and more frequent and diverse workload actions compared to MMB, which was used with versions of Exchange prior to Exchange 2000. MMB2 more accurately reflects the increased workload seen by customers as they increasingly rely on messaging services deployed in today's heavy corporate e-mail environments.

<sup>2</sup> When running in 32-bit mode.

Data current as of May 27, 2003.

<http://www.microsoft.com/exchange/techinfo/planning/2000/perfscal.asp>

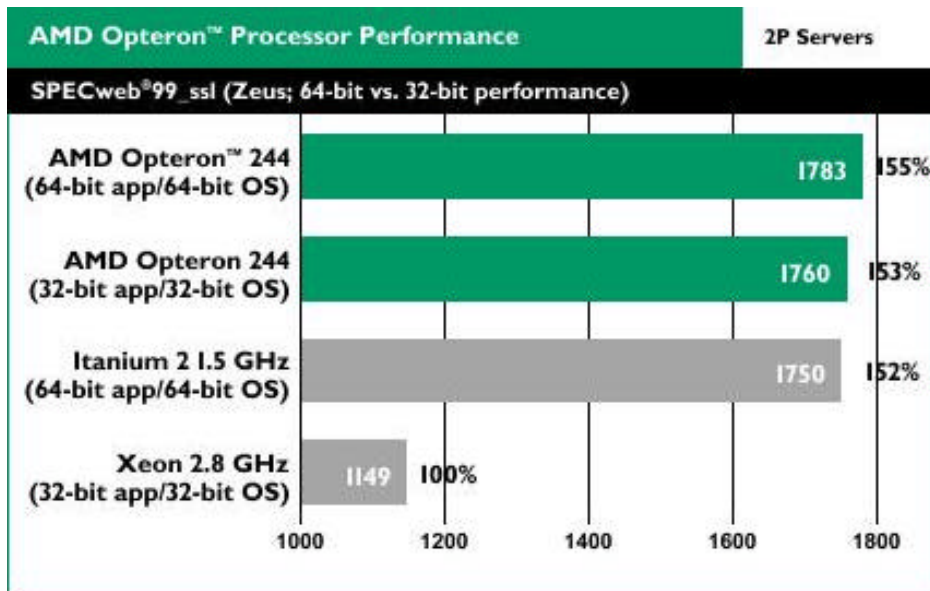


# Benchmarks

## SpecWeb®99 32-bit vs. 64-bit performance

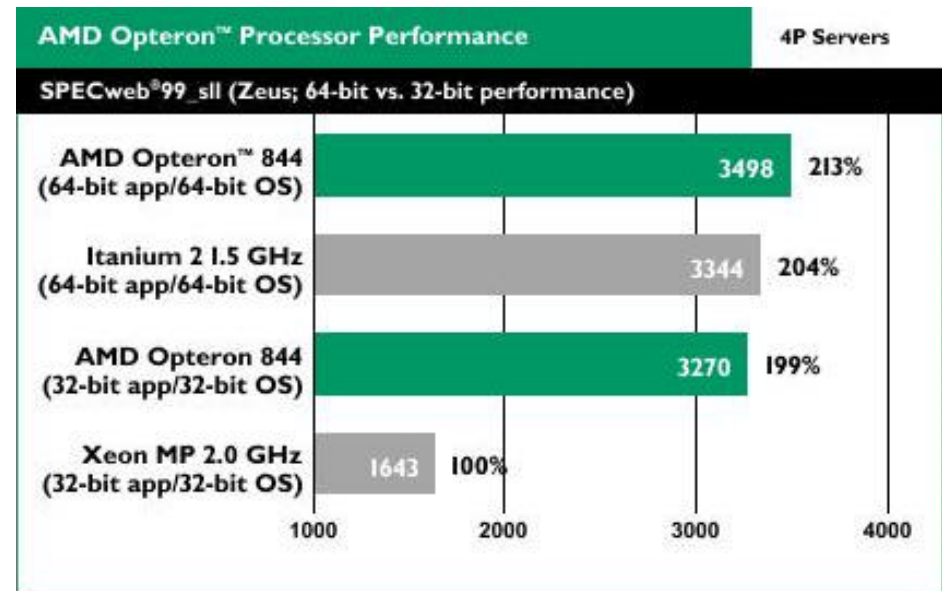


### 2P Servers



SPEC and the benchmark name SPECweb are registered trademarks of the Standard Performance Evaluation Corporation. Competitive benchmark results stated above reflect results published on [www.spec.org](http://www.spec.org) as of Apr 16, 2003. SPEC scores for AMD Opteron processor based systems are under submission to SPEC organization. For the latest SPECweb benchmark results, visit <http://www.spec.org/web99ssl>.

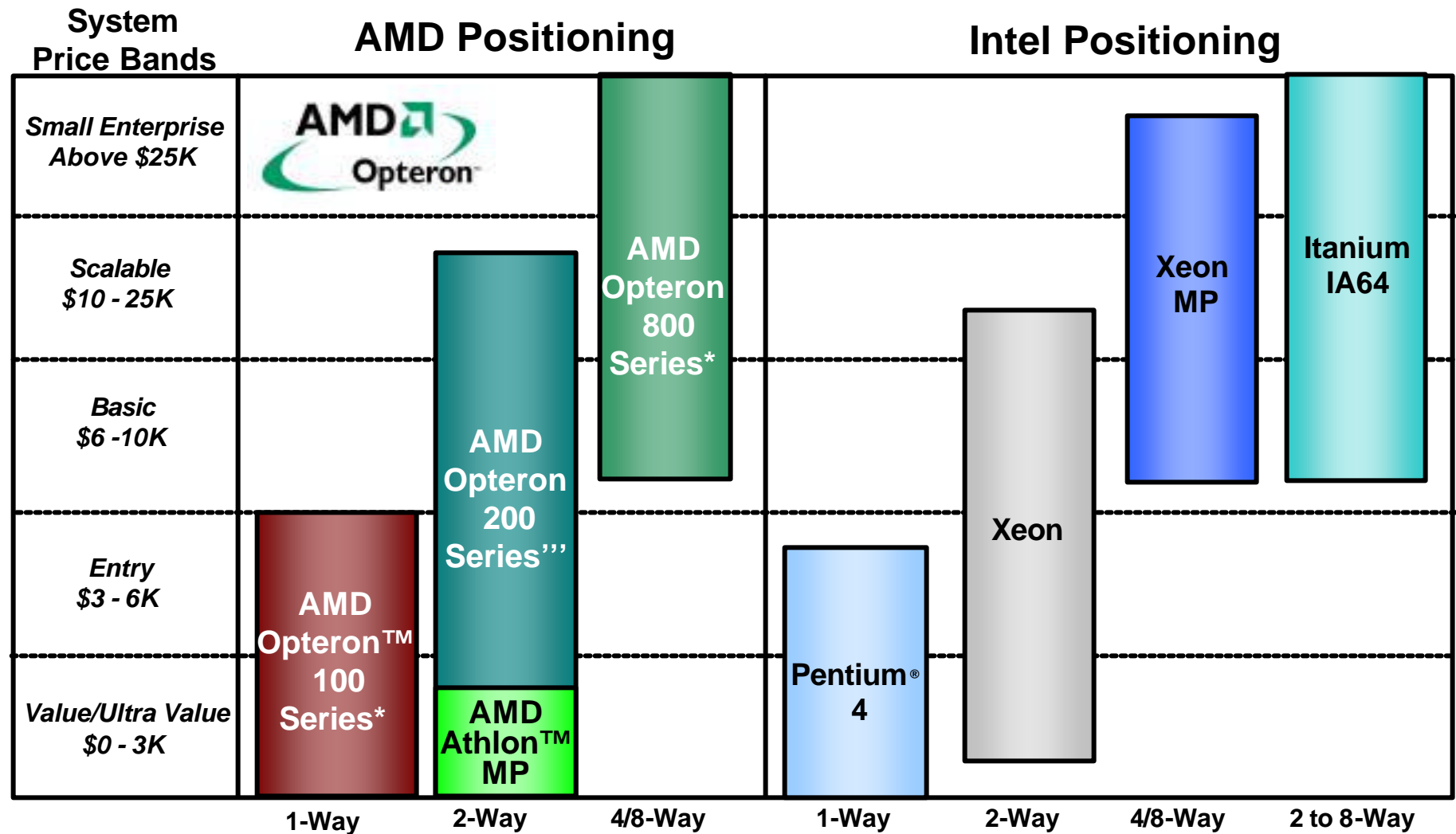
### 4P Servers



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# AMD Opteron™ Competitive Price Positioning

## 2003 Server Competitive Landscape



\*Planned availability 2Q03



# Notable Quotes



AMD's Opteron™ "is a nice smooth migration story from 32-bit to 64-bit without having to go through the application adjustment process. Companies don't have to make changes or suffer performance degradation."

(Jeff Jones, director of strategy for IBM Data Management Solutions; 12/13/02 ZDnet)

"An IBM software engineer at AMD's booth said that it only took the company two days to port the database (DB2) to the new [AMD] Opteron processors."

(ITWorld 8/15/02)

"Learning EPIC instructions will take time. It will take 15 years to educate people about it. That's half a generation, and I am getting old."

(Len Tsai, chief architect at NEC; 7/17/2002 Infoworld "Panel debates the merits of Itanium®")

"We are not seeing or hearing anything from our customers and ISVs that indicates they want or need Itanium. But we are seeing interest for the upcoming [AMD] Opteron processor family, essentially because it has 32-node compatibility, which Itanium doesn't."

(John Loiacono, VP of Sun's operating platforms group, Eweek 3/31/03)

Jim Allchin, the man in charge of Microsoft's operating systems, calls the performance of software on the AMD machines "pretty amazing."

(Fortune 2/3/03, "See this Chip?")

"We (Microsoft) are pleased to help usher in a new era of business value by extending our ongoing investment in 64-bit computing to the AMD platform."

(Brian Valentine, senior vice president of Microsoft's Windows Division, March 2003)



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